

DOCUMENT RESUME

ED 317 604

TM 014 706

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TITLE The ETS Factor-Referenced Kit in the Light of New Reanalyses of Classic Factor-Analytic Studies.
PUB DATE 26 Mar 90
NOTE 13p.; Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April 16-20, 1990).
PUB TYPE Information Analyses (070) -- Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Auditory Perception; *Cognitive Tests; Concept Formation; Creativity Tests; Critical Thinking; *Factor Analysis; Language Tests; Literature Reviews; Matrices; Memory; Visual Perception
IDENTIFIERS Data Sets; Educational Testing Service; *Exploratory Factor Analysis; *Factor Referenced Kits

ABSTRACT

The factor-referenced kits developed by the Educational Testing Service (ETS) are assessed. With support from the National Science Foundation, the researcher surveyed the total range of research done over the past 65 years on the identification of cognitive abilities, principally through factor analysis. From a corpus of an estimated 2,000 data sets in the literature, 450 data sets were analyzed using hierarchical exploratory factor analytic procedures. For most of the selected data sets, it was possible to reanalyze the correlation matrix associated with each data set. However, in some cases, it was necessary to accept the factor matrix derived by the original authors, to be rotated and if necessary subjected to higher-order factor analysis. The criteria for the number of factors to be extracted were generally conservative. Results include more than 10,000 variables and nearly 2,300 first-order factors and 600 higher-order factors identified in the data sets. Domains considered included language abilities; reasoning, thinking, and concept formation; memory and learning; visual perception; auditory reception; idea production; and speed of information processing. It appears that, on the whole, the 1976 ETS factor kit does a reasonably good job in covering the identified domains of cognitive ability, but that the kit could be significantly improved. An outline of the domains is included. (TJH)

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THE ETS FACTOR-REFERENCED KIT IN THE LIGHT OF NEW
REANALYSES OF CLASSIC FACTOR-ANALYTIC STUDIES

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The ETS Factor-Referenced Kit in the Light of
New Reanalyses of Classic Factor-Analytic Studies

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(For presentation at the meeting of the American Educational
Research Association, Boston, April 18, 1990)

The ETS factor-referenced kits, in the original 1954 version and in successive revisions of 1963 (French, Ekstrom, & Price, 1963) and 1976 (Ekstrom, French, & Harman, 1976), have been notable contributions to research on cognitive abilities. I have been proud to have had some part in their development, and I highly respect the work that John French, Ruth Ekstrom, the late Harry Harman, and others have done to make their issuance possible. Nevertheless the kits must be used with some caution, and approached with a critical eye. They have shortcomings, some attributable to the practical realities of constructing a useful series of tests, others attributable to our lack of adequate and certain knowledge as to what the latent traits of cognitive ability really are, and how they should be best measured. Over the past decade I have been devoting most of my scholarly energies to trying to answer this latter question.

With the support of the National Science Foundation, I have been surveying the total range of research that has been done over

the past 65 years or so--all the way back to studies by Spearman and his students--on the identification of cognitive abilities, principally through factor analysis. From a corpus of what I estimate consists of about 2000 datasets in the literature--in published studies, dissertations, and other sources--, I have selected more than 450 datasets to reanalyze through procedures that I consider up-to-date and appropriate for the purpose, procedures that can be described by the term hierarchical exploratory factor analysis. These 450 or more datasets include most of the classic studies of Thurstone, Guilford, Cattell, and Horn, plus others (both early and more recent) that I believed would yield results of interest. In most cases I have been able to reanalyze the correlation matrix associated with each dataset; in some cases, however, I have had to accept the factor matrix derived by the original authors, to be rotated and if necessary subjected to higher-order factor analysis. My criteria for the number of factors to be extracted have generally been conservative, often using, for example, the Montanelli-Humphreys criterion (Montanelli & Humphreys, 1976) as adapted by Tucker (personal communication). Rotations of factor matrices have followed a consistent plan, generally using procedures recently developed by Tucker and Finkbeiner (1981; Tucker, personal communication). Wherever possible I have performed Schmid-Leiman orthogonalization of the higher-order results (Schmid & Leiman, 1957).

The outcomes of this effort have been massive and complex. More than 10,000 variables are involved in the datasets I have

analyzed, and I have identified nearly 2300 first-order factors in the studies, in addition to nearly 600 higher-order factors. I call these "token factors" because of course they are not all different: the problem is to reduce them to a list of well confirmed factor types, corresponding to presumed latent traits. In doing this I have had to look carefully at the nature of the variables employed, the types of samples, the conditions of administration, and other matters. There are many unresolved questions--information on the variables is often inadequate, many factors are difficult to interpret, and so forth. At this time, although I have completed all the reanalyses, I have not yet been able to sort through all the voluminous results. Nevertheless, I have worked through enough of the results to render some judgments about the adequacy of the ETS kits in covering the domain of cognitive abilities and in offering tests to measure the latent traits of that domain. A more complete account of my work will appear, I trust, in a book that is in preparation.

It is obvious that in the limited time at my disposal, I cannot report all the details of my analyses. What I have done is to prepare a handout, presumably now in your hands, that simply reports results for what can be regarded as first-order factors, in such a way that we can compare the ETS Kit factors with the factors identified in my analyses. The ETS Kit is concerned only with first-order factors, and I do not have time to discuss higher-order factors. Nor do I have time to pay much attention to the tests offered by the ETS kit for measuring the respective factors.

I should point out that there is a certain degree of circularity in comparing ETS Kit factors with those of my reanalyses, because the ETS kit tests (or tests like them) have substantial representation in the datasets I have reanalyzed. However, the effects of circularity are considerably minimized by the fact that my datasets involve far more variables than simply the ETS kit tests, and in many respects, I believe, my procedures of analysis are more advanced than those previously used.

Note that in the handout, the ETS kit factors are listed in a left-hand column, while the factors identified in my reanalyses are listed in a right-hand column. Whenever an ETS kit factor can be cross-identified with a "reanalysis" factor, I have so indicated with a line connecting the factors. I use two-character symbols to identify factors, using the ETS kit symbols as far as possible, but occasionally altering them where I believe a more appropriate mnemonic is justified. And, of course, my reanalyses identify many more factors than are recognized in the ETS kits. In all, the handout lists 57 factors identified in reanalyses, but there are a number of others not listed.

For convenience, I classify factors into a number of "domains," partly in terms of content, and partly in terms of process. I find it inadvisable to use Guilford's (1967) taxonomic system, which, incidentally, my results do not confirm.

Consider first the domain of language abilities. (Note that some "language abilities" are listed in a domain of "idea

production," on the third page of the handout; I will mention them later). The striking point here is that the ETS kit is in a sense very deficient in measuring language abilities. The Kit factor V: Verbal Comprehension corresponds most closely to a factor that I identify as VL, Lexical Knowledge and General Information. In the ETS kit, factor V is measured only by vocabulary tests. True, printed vocabulary tests are generally substantially correlated with other possible measures of language abilities, such as reading comprehension, listening comprehension, and writing. But my reanalyses, which incidentally are based on datasets administered to a wide range of ages or grades, indicate that a number of linearly independent dimensions can be identified in this domain, particularly if the tests are not restricted to printed paper-and-pencil multiple-choice tests. The names I have given to the 14 reanalysis factors listed will, I trust, give you an impression of the varieties of abilities measurable in the language domain--even if we restrict the focus to native language abilities.

In the domain of reasoning, thinking, and concept formation, the ETS kit is much more successful in covering the territory. I have reinterpreted several of the factors, however. What the kit calls RL: Logical Reasoning I have renamed RG: General Sequential Reasoning. What the kit calls RG: General Reasoning, I have renamed RQ: Quantitative Reasoning. My reanalyses do not support a factor IP: Integrative Processes, but this may be due to inadequate representation and testing of such a factor in my datasets. My Induction factor, incidentally, seems to cover

various tests of concept formation ability.

The three Kit factors in the domain of memory correspond reasonably well to reanalysis factors, except that the evidence for a separate visual memory factor is weak. At least two other reanalysis factors, M6 (free recall) and MM (meaningful memory) are probably important enough to be included in future editions of the Kit.

In my reanalyses, the domain of visual perception is very complex: I have tried to indicate the proper interpretation of the factors by brief phrases attached to each factor name. The domain is fairly well covered by the Kit, at least in terms of factors identified. The tests offered by the Kit are not always the most appropriate ones, or they could be improved by further attention to difficulty levels and time-limit problems. My reanalyses do not support a CV: Verbal Closure factor; performance on verbal closure tests can be accounted for by other factors, either in the visual perception or the language domain. My reanalyses reveal several factors not covered by the Kit: PI: Serial Perceptual Integration, IL: Resistance to Illusory Effects, and PA: Perceptual Alternations. However, testing of these factors would involve fairly elaborate experimental procedures that might be considered impractical for a future Kit.

My reanalyses reveal numerous factors in the domain of auditory reception, as listed. This domain is not covered at all by the ETS Kit. Whether it would be practical to do so in future versions of the Kit is debatable, because the variables

universally involve auditorily-presented stimuli.

I define a domain of idea production in terms of the fact that all factors identified in it involve production of responses representing "ideas" in some form--verbal or figural; none involves anything like a multiple-choice format. The domain is fairly well taken care of by ETS Kit tests and their factors. The factors FI, FA, FE, FW, FF, and XF of the 1976 Kit are generally well confirmed in my reanalyses; in addition, factors Sep and O of the 1963 kit (not included in the 1976 kit) are confirmed. Factor XU of the 1976 Kit does not seem to be confirmed; its tests can usually be accounted for by the SP (Sensitivity to Problems) factor. My reanalyses identify a factor NA: Naming Facility, that could easily be included in any future version of the Kit.

Finally, I need only mention the well-known N: Number factor that is well-confirmed in reanalyses, allotted to a domain of "speed of information processing" that I have not yet had opportunity to consider in detail.

I can conclude that on the whole and with some notable exceptions, the 1976 ETS factor kit does a reasonably good job in covering the domains of cognitive ability that I have identified. On the basis of present knowledge, however, it would undoubtedly be possible to develop a much improved Kit for research purposes. More factors would be included, and the tests would in many cases be better selected, or redesigned. I would particularly recommend closer attention to the matter of distinguishing between speed (rate of performance) and level of mastery. A majority of present

Kit tests are usually administered and scored in such a way that these distinct dimensions are confounded. It is difficult to know the status of many of the factors with respect to speed and level of mastery.

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HANDOUT (AERA meeting, Boston, April 18, 1990, session 27.03)

The ETS Factor-Referenced Kit in the Light of
New Reanalyses of Classic Factor-Analytic Studies

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ETS KIT FACTORS

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REANALYSIS FACTORS

DOMAIN: LANGUAGE ABILITIES

LD: Language Development
LS: Listening Ability/Comprehension
OP: Oral Production
CM: Communicative Ability (tentative)
V: Printed Language Comprehension, General
V: Verbal Comprehension<->VL: Lexical Knowledge/General Information
RC: Reading Comprehension
RD: Reading Decoding
RS: Reading Speed
CZ: Cloze Ability
SG: Spelling Ability
PC: Phonetic Coding
MY: Grammatical Sensitivity
WP: Writing Production (tentative)

DOMAIN: REASONING, THINKING, CONCEPT FORMATION

RL: Logical Reasoning<---->RG: General Sequential Reasoning
I: Induction<----->I: Induction
RG: General Reasoning<---->RD: Quantitative Reasoning
IP: Integrative Processes<> (not supported in reanalyses)
RP: "Piagetian Reasoning" (unclear status
relative to the other factors in this
domain)

DOMAIN: MEMORY AND LEARNING

MS: Memory Span<----->MS: Memory Span
MA: Associative Memory<--->MA: Associative Memory
M6: Free Recall Memory
MM: Meaningful Memory (memory for ideas,
events)
MV: Visual Memory<----->MV: Visual Memory (?; weak evidence)
[Several learning ability factors omitted
here]

(continued)

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ETS KIT FACTORS

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REANALYSIS FACTORS

DOMAIN: VISUAL PERCEPTION

VZ: Visualization<----->VZ: Visualization (apprehend spatial
entities; level of difficulty)
S: Spatial Orientation<--->SR: Spatial Relations (speeded rotation/
reflection)
CS: Speed of Closure<----->CS: Closure Speed (apprehend spatial entity
with distortion; speed)
CF: Flexibility of
Closure<----->CF: Flexibility of Closure (detect/diseased
given spatial entity from complex array)
PI: Serial Perceptual Integration
SS: Spatial Scanning<----->SS: Spatial Scanning (weak evidence)
P: Perceptual Speed<----->P: Perceptual Speed (locate/compare spatial
entities)
LE: Length Estimation<----->LE: Length Estimation
(in 1963 kit)
IL: Resistance to Illusory Effects
PA: Perceptual Alternations
CV: Verbal Closure
(not supported in reanalyses)

DOMAIN: AUDITORY RECEPTION

[no factors in ETS
kits]

UA: Hearing & Speech Thresholds
US: Speech Sound Discrimination
U1: Auditory Cognitive Relations
U3: General Tonal Discrimination
U5: Pitch/Frequency Discrimination
U6: Sound Intensity/Duration Discrimination
U1: Tonal Imagery
U9: Musical Sensitivity/Judgment
UR: Resistance to Auditory Stim. Distortion
UK: Temporal Tracking (not necessarily
auditory)
US: Maintaining Rhythm (not necessarily
auditory)
UM: Memory for Sound Patterns
UP: Absolute Pitch Ability (inferred from
non-factorial evidence)
UL: Sound Localization (?)

(continued)

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ETS KIT FACTORS

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REANALYSIS FACTORS

DOMAIN: IDEA PRODUCTION

FI:Ideational Fluency<--->FI: Ideational Fluency
NA: Naming Facility
FA:Associational Fluency<>FA: Associational Fluency
FE:Expressional Fluency<->FE: Expressional Fluency
FW:Word Fluency<----->FW: Word Fluency
Sep:Sensitivity to
Problems (1963 kit)<---->SP: Sensitivity to Problems
O:Originality (1963 kit)<>FO: Originality/Creativity
FF:Figural Fluency<----->FF: Figural Fluency
XF:Figural Flexibility<-->FX: Figural Flexibility
XU:Flexibility of Use
(not supported in reanalyses; similar to SP?)

DOMAIN: SPEED OF INFORMATION PROCESSING

N:Number Facility<----->N: Numerical Facility
[Other factors in this domain have not
yet been classified; e.g. Reaction Time]

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